Impacts of climate change and shifting fire regime on boreal post-fire successional trajectory
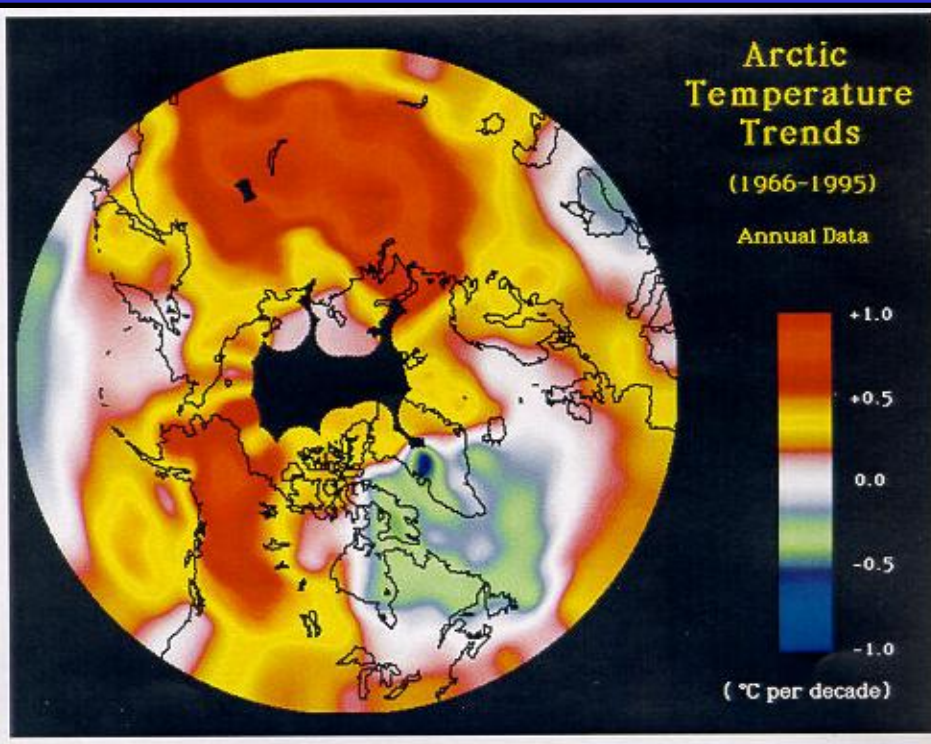
Teresa Hollingsworth

USDA Forest Service, PNW Research Station
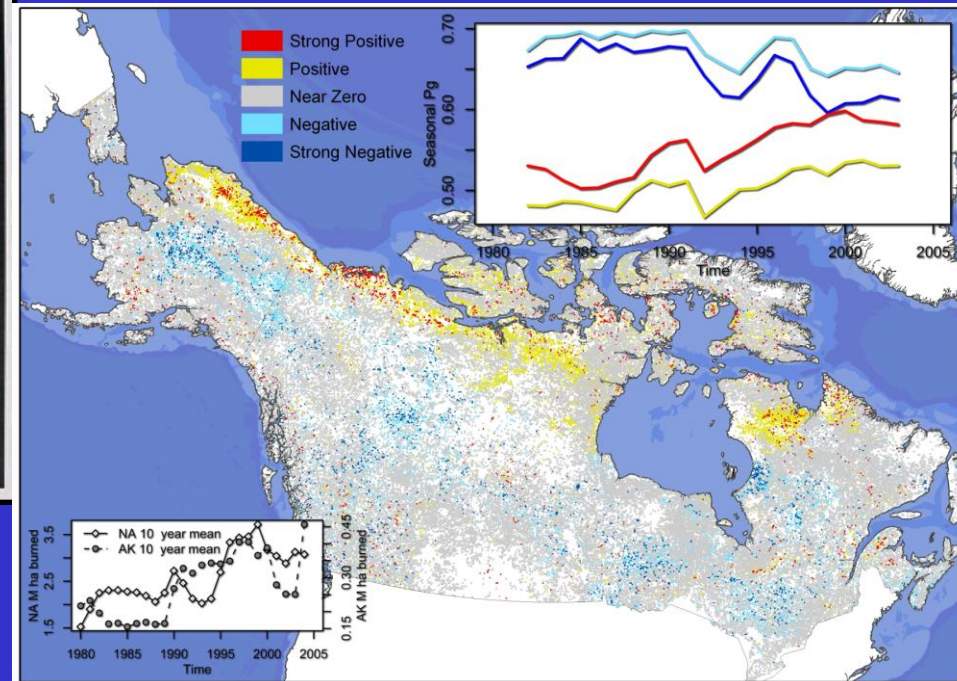
Jill Johnstone

University of Saskatchewan and University of Alaska Fairbanks

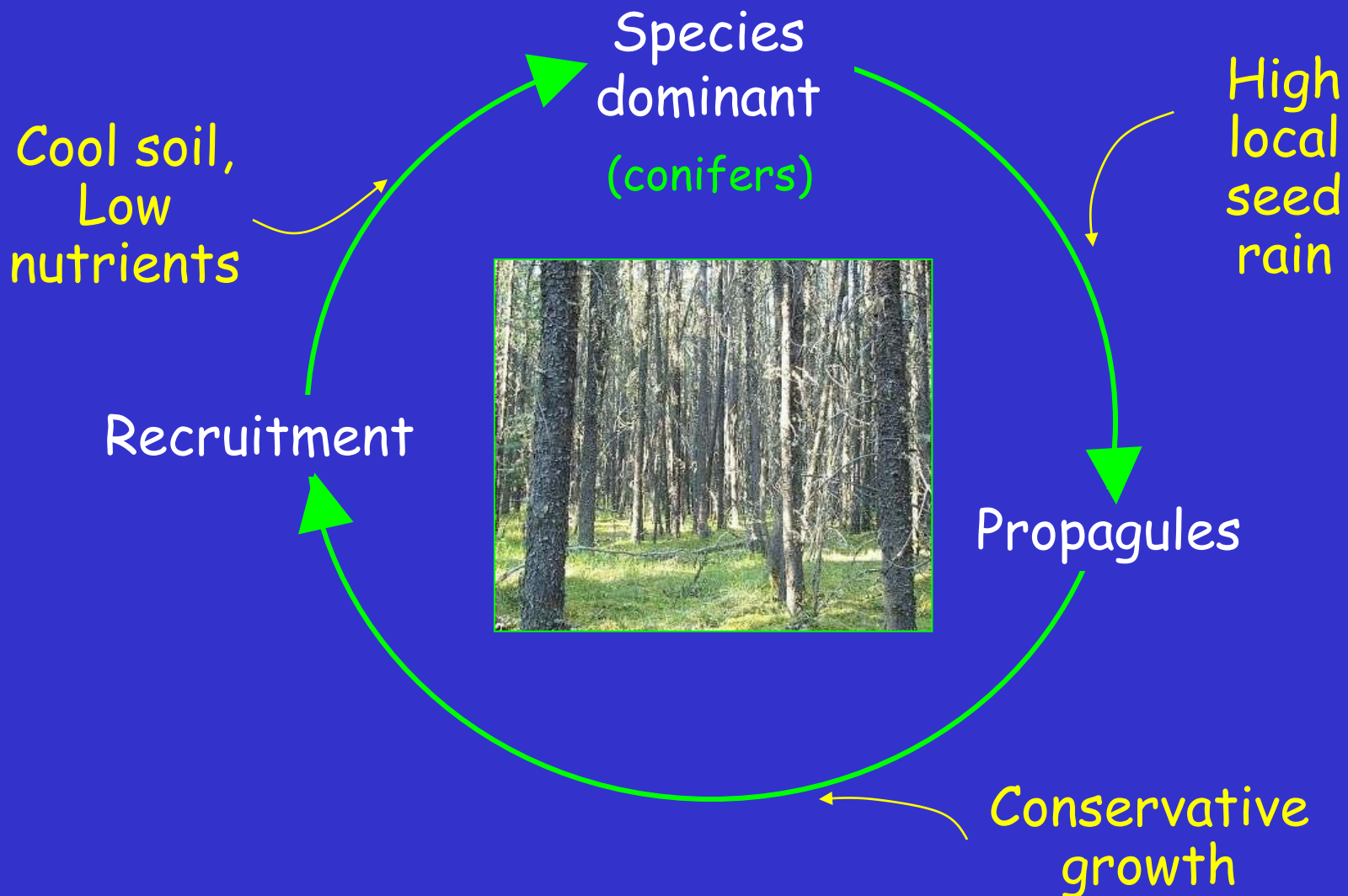# Climate Change & Fire

Chapin *et al.* 2005

Goetz *et al.* 2005

How are changes in fire regime likely to affect ecosystem responses to climate change?
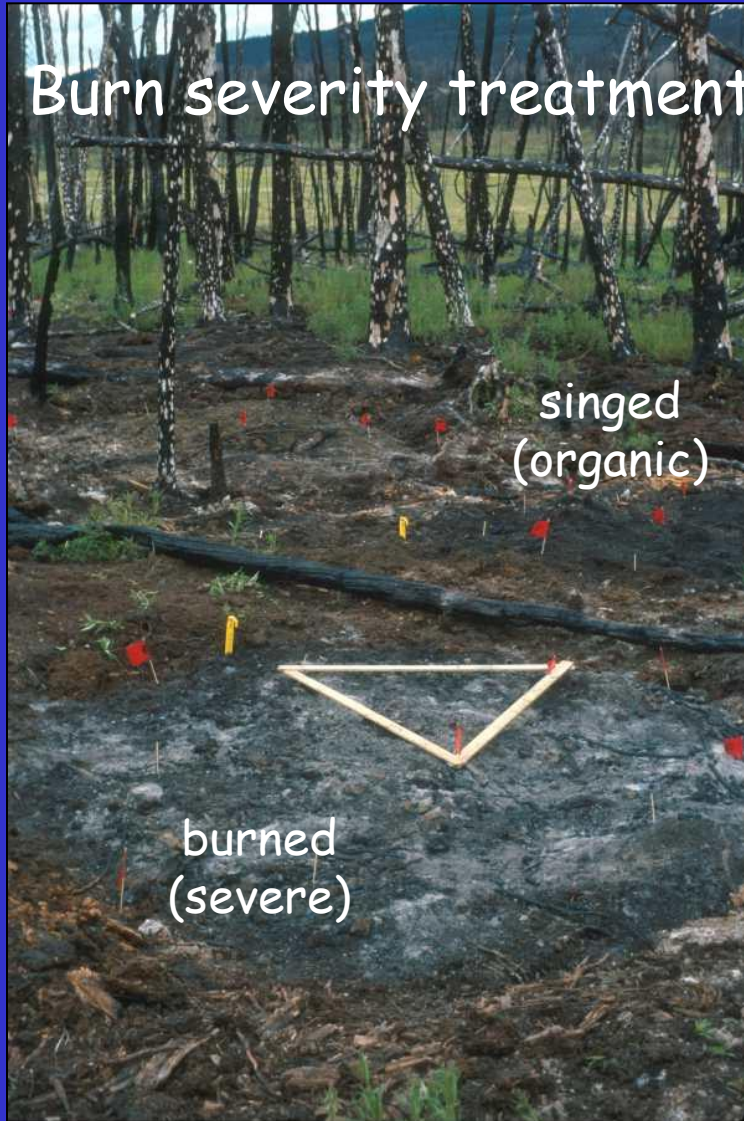
Can changes in fire severity in drive changes in boreal forests?

Boreal Forest

Species dominant (conifers)

High local seed rain

Cool soil, Low nutrients

Recruitment

Propagules

Conservative growth

Experimental effects of fire severity

Burn severity treatment

singed
(organic)

burned
(severe)

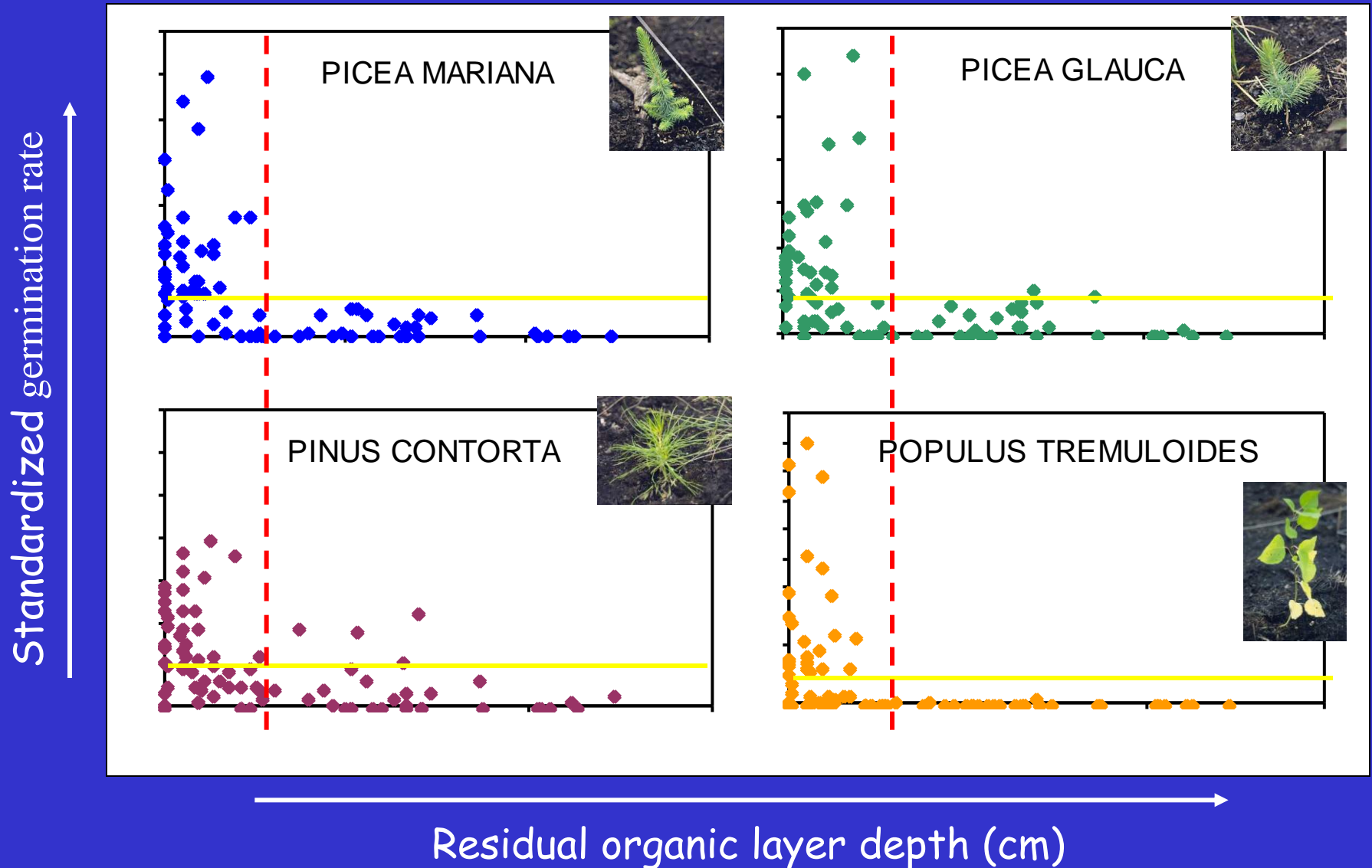Johnstone & Chapin (2006) *Ecosystems* 9: 14-31.

Seeding treatment:

- *Pinus contorta* (lodgepole pine)
- *Picea glauca* (white spruce)
- *Picea mariana* (black spruce)
- *Populus tremuloides* (aspen)

Experimental germination response

Standardized germination rate

Residual organic layer depth (cm)

PICEA MARIANA

PICEA GLAUCA

PINUS CONTORTA

POPULUS TREMULOIDES

Johnstone & Chapin (2006) *Ecosystems* 9: 14-31.

Summary: experimental responses

Low severity (organic)

- Poor seedbeds
- Recruitment requires high seed inputs
- Strongly favors conifers

High severity (mineral)

- Higher quality seedbeds
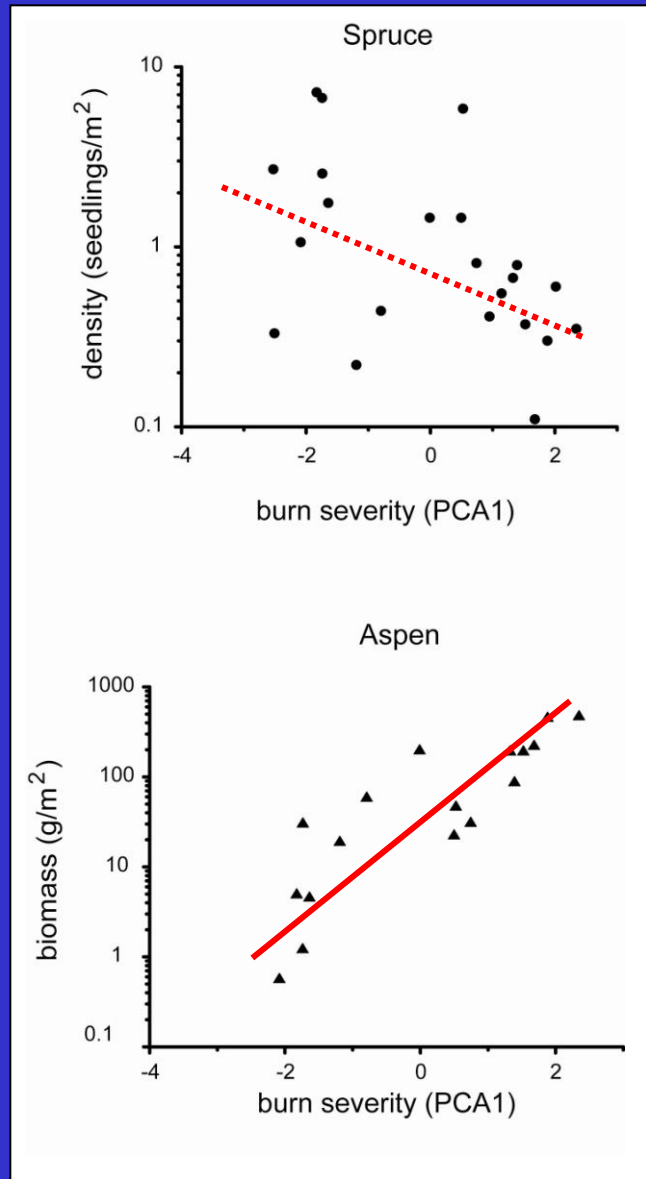- Creates opportunity of deciduous establishment
- Promotes change

Scaling up: From small plots to a large wildfire

Tree seedling responses

- ## Spruce
  – Weak negative response
  – Contrary to experiments

- ## Aspen
  – Strong positive response
  – Consistent with experiments

Johnstone & Kasischke (2005) *Can. J. For. Res.* 35: 2151-2163.

JFSP Study Design

- 90 sites established in 2004 burns along Dalton, Taylor, and Steese Highways
- 32 intensive study sites
  - arranged across combinations of high-low site moisture & high-low burn severity
- 7 treeline sites
- Detailed pre-fire stand data available for 14 sites
- Reconstruction of pre-fire conditions at remaining sites
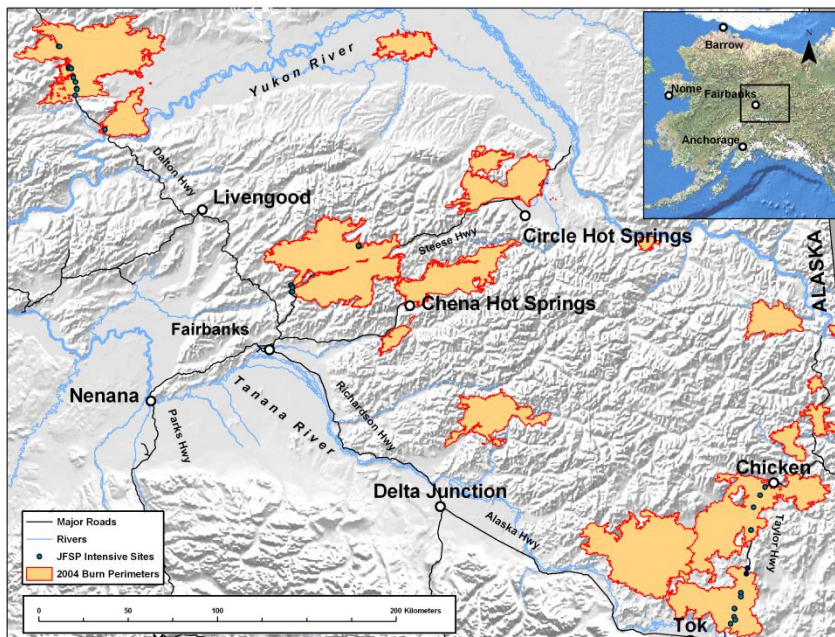
JFSP Study Design (cont.)

Low

High

Dry

Wet

What drives natural post-fire seedling recruitment across multiple fires?

## Differential sensitivity of functional groups to site characteristics and fire regime

-Spruce recruitment (as measured by post-fire seedling density) is most influenced by elevation, pre-fire spruce density, and site moisture.

-Fire severity (CBI) and stand age had weaker effects

-50 % of Deciduous recruitment can be explained by fire severity; also important were elevation, latitude, moisture, and distance to nearest unburned deciduous stand.

What drives natural post-fire seedling recruitment across multiple fires?

-The ratio of spruce/deciduous recruitment is driven by the relationship between deciduous and fire severity.

Important role of fire severity in "tipping" the balance between coniferous and deciduous dominance

Johnstone, Hollingsworth, Chapin, and Mack (2010) *Global Change Biology 16:1281-1285*

What drives post-fire vegetation composition across multiple fires?
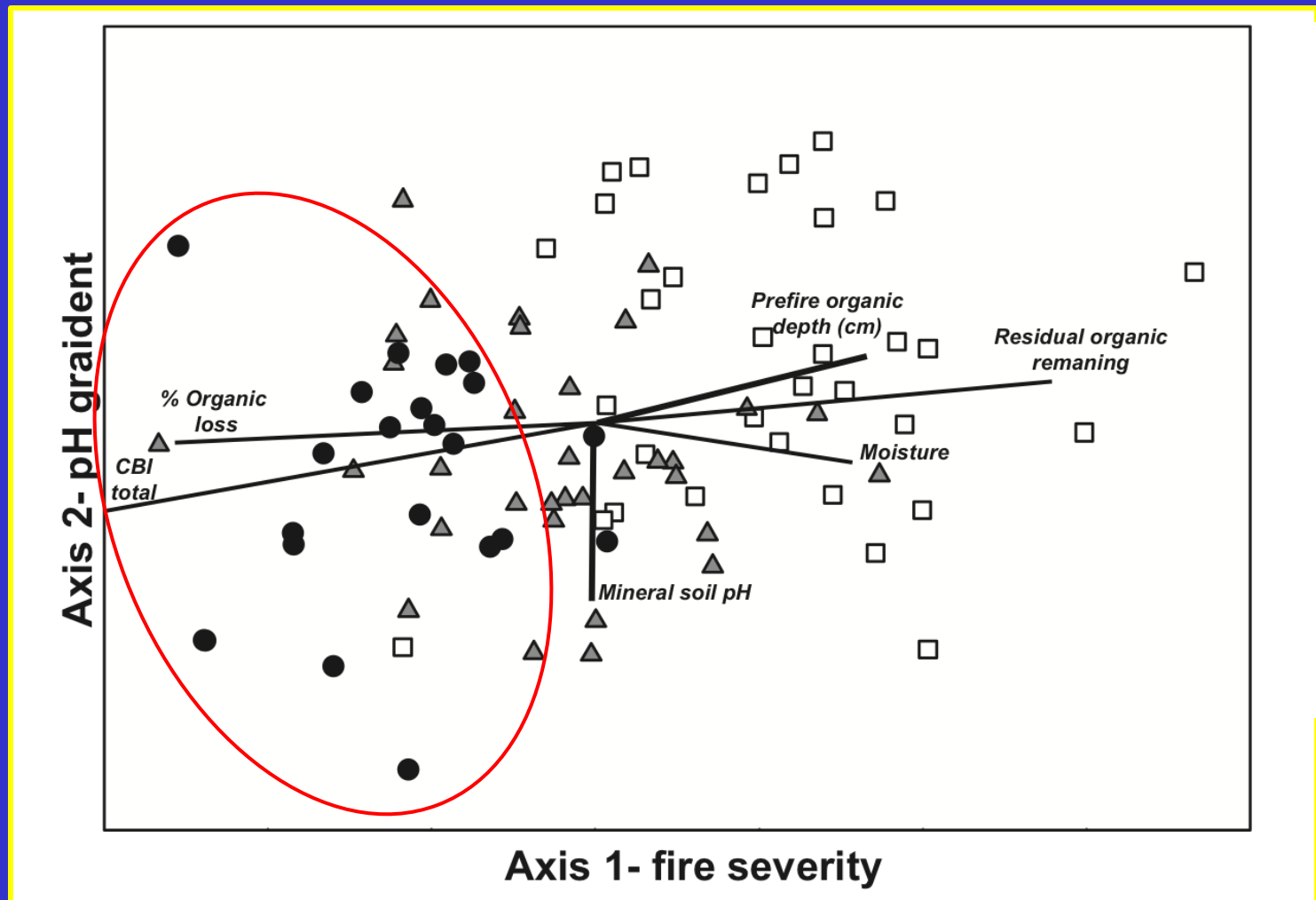
Burn severity is HIGHLY correlated with the Axis 1

What drives post-fire vegetation composition across multiple fires?

Bernhardt, Hollingsworth, and Chapin (in press) *Journal of Vegetation Science*
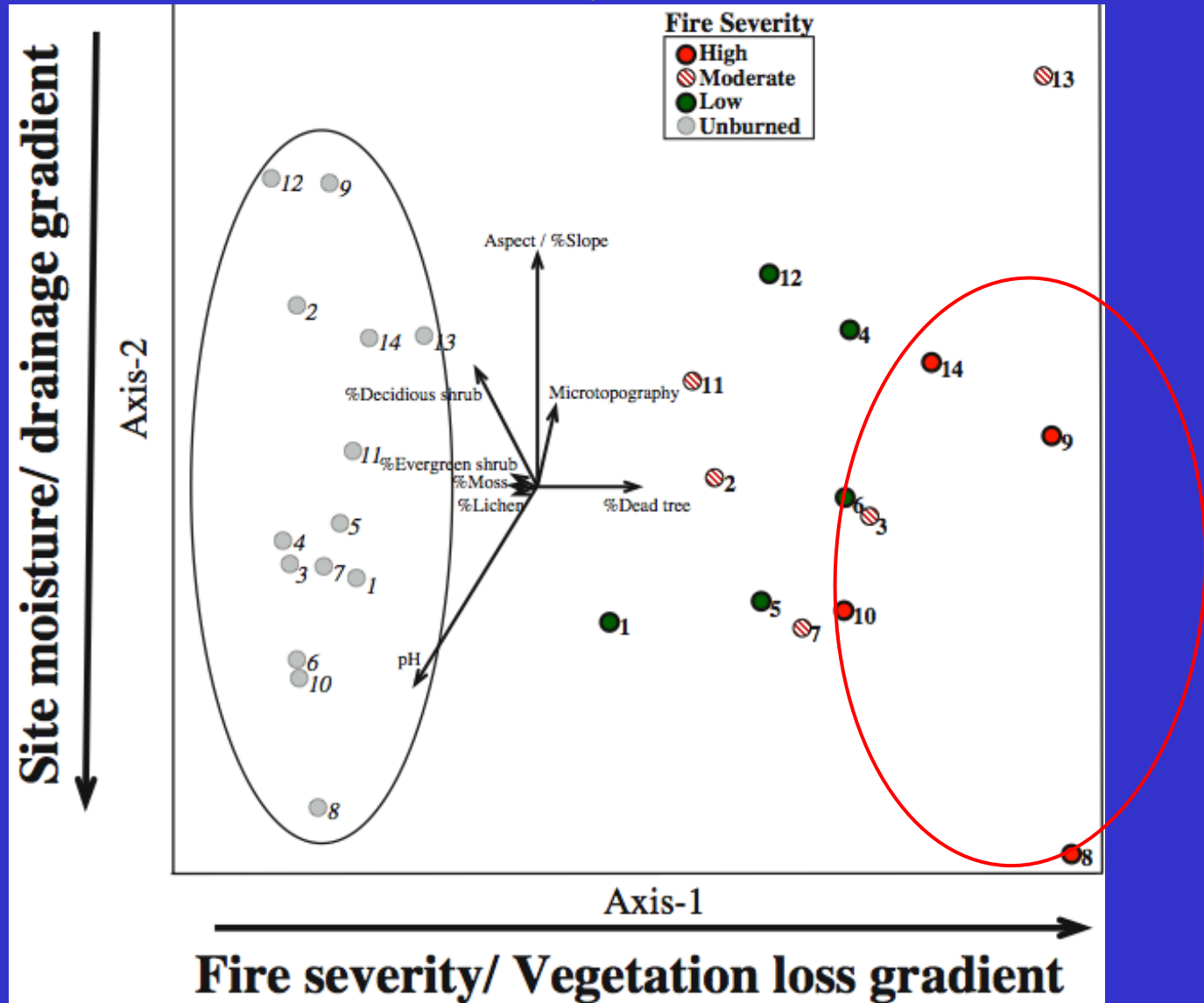
Climate response dynamics

- Regeneration feedbacks => resilience/inertia

- Climate change sets the stage

- Disturbance must 'provoke' the response

Johnstone, Chapin, Hollingsworth, Mack, Romanovsky, and Turetsky (2010) *CJFR* 40: 1302-1312
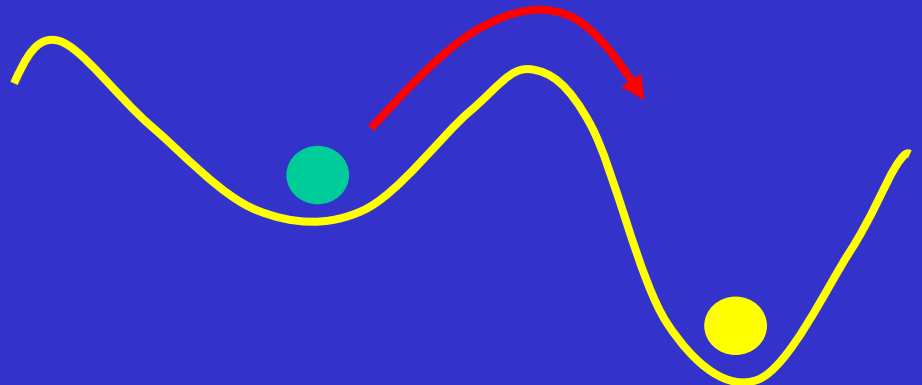
Concluding remarks

➢ Fire as a catalyst and driver of change

- Critical & sensitive post-fire window

- Strong severity effects on recruitment patterns

- Influence on successional trajectories apparent at multiple scales

➢ Landscape context and vulnerability to change

Collaborators:

Terry Chapin

Michelle Mack

Ted Schuur

Dave Verbyla

Bonanza Creek